LAND-USE PATTERNS SURROUNDING GREATER PRAIRIE-CHICKEN LEKS IN NORTHWESTERN MINNESOTA

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Abstract: To better manage wildlife populations, managers must know which combination of land uses creates optimal habitat. We used spatial analysis at a landscape scale to describe land-use patterns and patch characteristics surrounding leks of greater prairie-chicken (*Tympanuchus cupido pinnatus* L.) in the Agassiz Beach Ridges (ABR) landscape (2,467 km^2) in northwest Minnesota. We hypothesized that types and patterns of land use favorable to greater prairie-chickens would be associated positively with lek versus non-lek points, and particularly more stable (traditional) leks. Using a Geographic Information System (GIS), we analyzed land-use proportions and patch characteristics within an 810-ha area (1.6-km radius) surrounding traditional leks, temporary leks, and randomly located non-lek points. We found locations of greater prairie-chicken leks were strongly dependent on land use as revealed by a multivariate analysis of variance (MANOVA; $P < 0.001$). A discriminant function analysis and univariate analysis of variance (ANOVA) showed that several land-use characteristics were associated most strongly with leks: smaller amounts of residential–farmstead, smaller amounts and smaller patches of forest, and greater amounts of Conservation Reserve Program (CRP) lands. Comparisons between traditional and temporary leks revealed that traditional leks were surrounded by a lesser proportion of forest and cropland than were temporary leks ($P < 0.001$). Univariate ANOVAs showed that traditional leks also were associated with larger patches of grassland ($P < 0.001$), and grassland ($P = 0.016$) and forest patches ($P = 0.017$) having more irregular shapes. Our study suggests efforts to manage and conserve greater prairie-chicken populations in the Tallgrass Prairie Region should focus on landscape-scale land-use patterns in addition to local habitat characteristics. Landscape-scale efforts could include enlarging grasslands around traditional leks by completing prairie restorations and CRP plantings, while local-scale strategies should seek to improve the quality of habitat in existing and new grassland areas.

JOURNAL OF WILDLIFE MANAGEMENT 63(1):189–198

Key words: Geographic Information Systems, GIS, greater prairie-chicken, land-use pattern, leks, patches, *Tympanuchus cupido pinnatus*.

Several researchers have established that permanent grassland is vital to the greater prairie-chicken (Hamerstrom et al. 1957, Jones 1963, Robel et al. 1970, Kirsch et al. 1973, Newell et al. 1987). Grasslands provide cover for nesting, brood rearing, roosting, and concealment from predators, as well as an abundant and diverse food supply (Kobriger 1965). In general, larger greater prairie-chicken populations are found near larger grassland patches (Hamerstrom and Hamerstrom 1973). Kirsch (1974) suggested the minimum management area for greater prairie-chickens was approximately 520 ha, with the smallest unit of grassland equal to 65 ha. Given the decrease and fragmentation of native grasslands in central North America, the greater prairie-chicken's range, not surprisingly, has contracted, and population numbers have declined (Westemeier 1980). In Minnesota, the greater prairie-chicken is listed as a species of special concern (Coffin and Pfannmuller 1988).

Studies of habitat patterns and preferences of greater prairie-chickens have used radiotelemetry or field observations and focused on nesting, brooding, courtship, roosting, and foraging areas. Landscape-scale studies are needed to understand species' distribution and habitat patterns over large areas (Weins 1989). For greater prairie-chickens, leks are an obvious focal point at the landscape scale because they are surveyed relatively easily over large areas. Half of all leks in 1 study (Schroeder and White 1993) and all leks in another (Svedarsky 1988) were located within 2 km of the nests of females

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visiting those leks, which suggested that the surrounding area meets certain habitat requirements such as nesting and brood-rearing cover for females. Not only does high-quality habitat influence where leks are located, males appear to choose lek locations based on proximity to females (Schroeder and White 1993).

We hypothesized that land-use patterns and some land-use patch characteristics (e.g. patch size, shape) surrounding leks would be different than land-use patterns and patch characteristics surrounding randomly located non-lek points. We also hypothesized that land-use patterns and patch characteristics surrounding more stable leks (i.e. traditional leks) would differ from patterns and patch characteristics surrounding temporary leks, assuming lek permanency was positively related to overall habitat quality. Permanent leks may be in areas with "better" nesting habitat, whereas Schroeder and Braun (1992) suggested temporary leks consisted of males unable to obtain territories on permanent leks. The permanency of leks should help us identify preferred greater prairie-chicken habitat as well as marginal habitat and suggest which differences in land-use patterns and patch characteristics are most important, with implications for management at the landscape scale. We used greater prairie-chicken leks and current land-use data to examine such relations across the ABR landscape of northwest Minnesota.

STUDY AREA

The ABR study area covers 2,467 km^2 in northwestern Minnesota and spans 6 counties within the Red River Valley (Fig. 1). The elongated shape of the landscape (about 200 km long and 3–30 km wide) follows the historic dunes and beach ridges created 10,000 years ago by former Glacial Lake Agassiz (Krenz and Leitch 1993). The native grassland ecosystem that once dominated the area has been highly fragmented by agriculture, roads, and urban development. Currently, the landscape is >73% cropland. However, since 1985, about 400 km^2 of cropland have been enrolled in the CRP, which has been planted primarily to a nonnative grass–forb mix (Rosenquist 1996).

Even with such intensive use, the ABR contains the largest tracts of native prairie in the state, due to underlying sandy and gravelly soils and the poor agronomic value of some areas. Because of large intact prairies and a mix of natural community types, the study area harbors the largest populations of the greater prairie-chicken in Minnesota (Svedarsky et al. 1997).

METHODS

Land-Use Data

We compiled and analyzed data for the ABR landscape in a vector-based GIS (ARC/VIEW, ARC/INFO). The ABR boundary was digitized by the Minnesota State Natural Heritage Program and followed the system of glacial dune ridges. The entire landscape was generalized to 14 land-use types interpreted and digitized from 1:24,000-scale 1990 aerial photos by the International Coalition for Land/Water Stewardship in the Red River Basin (cropland, transitional agriculture, forest, wetland, grass–shrub, grassland, urban, farmstead, rural residence, other rural residential, open water, gravel pits, exposed soil, unclassified). The minimum mapping unit was 2 ha. Land enrolled in CRP was not distinguished from other land-use types via the 1990 aerial photos; thus, we obtained a separate data coverage of CRP lands enrolled between 1985 and 1995 from the Minnesota Department of Agriculture. When we overlaid CRP with land-use data, approximately 92% of CRP coincided with agricultural uses (i.e., cropland and transitional agriculture). To correct for this data mismatch problem, cropland was decreased by the amount of overlapping CRP. The remaining 8% of CRP was classified as other land-use types such as native grasslands, wetlands, and grass–shrub areas. We did not change these land-use types to CRP. An additional classification error that we did not quantify or correct was that transitional agriculture (generally consisting of CRP and fallow land) also contained some burned native prairie.

For our analysis, we combined urban, farmsteads, rural residence, and other rural residential types into 1 class (i.e., residential–farmstead). Open water, gravel pits, exposed soil, and unclassified land-use classes were not analyzed because they accounted for only 0.6% of the landscape. Thus, we arrived at 8 land-use types for our analysis: cropland, CRP, transitional agriculture, residential–farmstead, forest, wetland, grass–shrub, and grassland.

Greater Prairie-Chicken Leks

We obtained greater prairie-chicken lek locations and number of males per lek for 1986–96 from the Minnesota Prairie Chicken Society

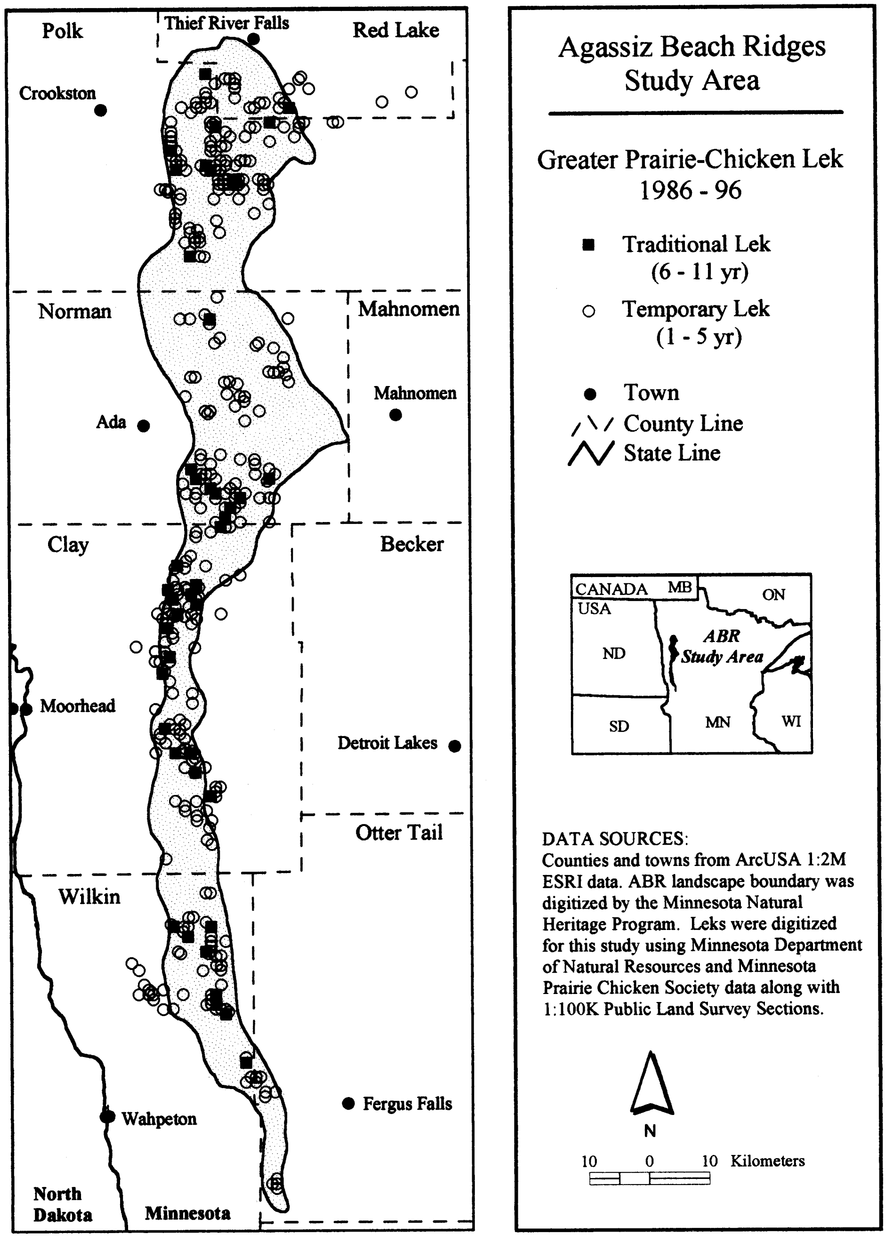

Fig. 1. Location of traditional and temporary greater prairie-chicken leks (1986–96) in the Agassiz Beach Ridges, northwestern Minnesota. Traditional leks were defined by presence of booming males in 6 years of the 11-year study period. Temporary leks were defined by use in ≤5 years.

(MNPCS) and the Minnesota Department of Natural Resources (MNDNR). Greater prairie-chicken leks were surveyed in each ABR county by MNPCS and MNDNR at times when male greater prairie-chickens were most active on leks. Observers drove highways and field roads, stopping at least every half mile to listen for the characteristic sound of displaying males. If a lek was not visible from the road, observers searched on foot and recorded the number of males and females they saw. Total area covered and thoroughness of county surveys varied somewhat depending on the number of staff or volunteers.

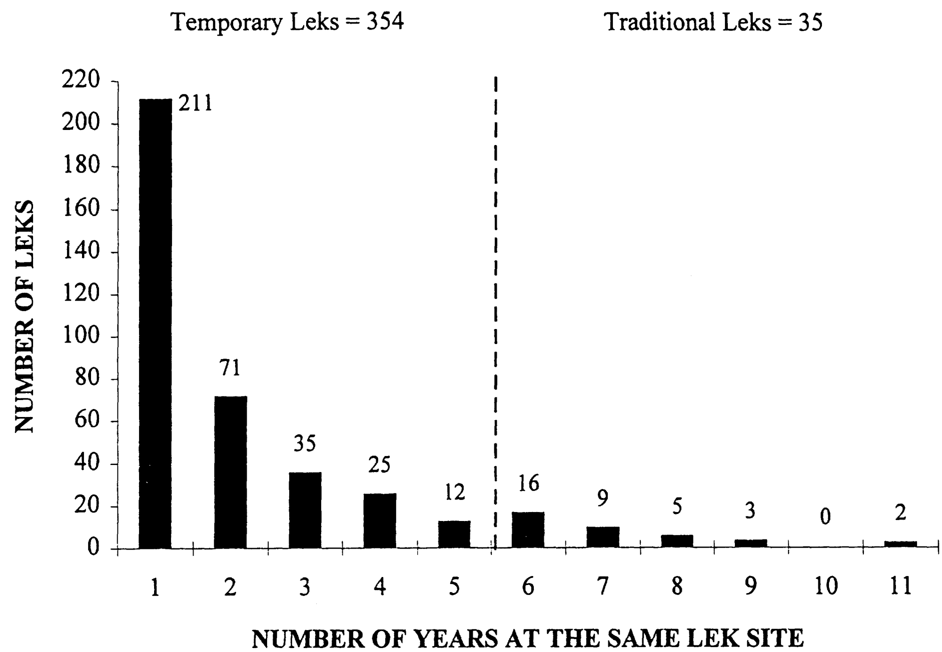

Fig. 2. Greater prairie-chicken lek usage in the Agassiz Beach Ridges, northwestern Minnesota, 1986–96.

For each lek, observers recorded the township, range, section, and, if possible, quarter section (approx 65 ha), but in most cases did not record the exact geographic coordinates. To digitize the leks in the absence of precise geographic coordinates (i.e., latitude and longitude or Universal Transverse Mercator coordinates), each lek was assigned to the center of the quarter section in which it was observed. If the location of the lek was not assigned to a specific quarter section by an observer, then the center of the whole section was used. In only a few instances were 2 leks recorded in the same quarter section in the same year. In these cases, 1 of the observations was omitted.

We analyzed lek stability over the 11 years and determined 2 categories based on the number of years a lek occurred in the same location. Definitions of lek stability vary greatly, are subjective, and few studies have determined quantitatively what constitutes a stable lek. The best example in the literature is Schroeder and Braun's (1993) study that determined lek stability based on consecutive use for a 6-year period and for a limited study area (301 km^2). In their study, only 25% of 80 leks were active all 6 years, and 23% of leks disappeared between years. However, their study focused on greater prairie-chicken attendance in relation to lek stability. Because our objective was to analyze land-use patterns around leks over a large landscape, our definition of stable did not require consecutive use. Instead, we identified leks that were used most frequently over the 11-year period. We used the term 'traditional' for those locations where displaying males occurred >50% of the period studied ($\geq$6 of 11 yr). We used the term 'temporary' for leks used in $\leq$5 years. This division is reasonable given the distribution of the ABR lek data (Fig. 2).

Location of leks can move slightly from year-to-year due to a disturbance (e.g. flooding or plowing). In addition, observer error or imprecision may account for slight shifts in recorded location from year-to-year. This resulted in misclassification of some leks as temporary when in fact they belonged to a group of adjacent leks that together constituted 1 traditional lek. To correct this problem, we examined lek density over the study area (using ARC/VIEW spatial analyst) and then manually checked areas that showed a high density of leks. We identified those leks that moved slightly and that could be combined as 1 location. For example, if we found a lek in a location in 1986 and again in 1988–91, and the adjacent quarter section had a lek in 1987 and 1992–93, we assumed there was a high probability that the same group of birds occupied both leks. We combined 2 such adjacent leks and counted them as 1 traditional lek (with an occurrence of 8 yr) rather than 2 temporary leks (with occurrences of 5 and 3 yr). All means are ± standard deviation.

Land-Use Patterns and Patch Characteristics

We analyzed land-use types within an 810-ha circle (1.6-km radius) surrounding each lek. The biological basis for this sampling area (distance) was from field studies describing male greater prairie-chicken daily movements, male home ranges during the mating season, nesting distance for females, and brood ranges. Although movements vary widely, depending on many environmental factors, males established at a lek tend to have reduced movements during the mating season (Robel et al. 1970). Fredrickson (1995) found average home range polygons of 185–251 ha for male greater prairie-chickens in South Dakota. Drobney and Sparrowe (1977) found distance of nests to nearest lek ranged from 46 to 805 m, whereas Toepfer (1988) recorded a 1.6-km distance, and Schroeder (1991) 1 km.

We compared the proportion of each land-use type within the 810-ha area around traditional leks, temporary leks, and randomly located non-lek points. We selected 100 random points from the set of quarter-section centroids that fell outside the 810-ha areas surrounding all lek locations. We performed a MANOVA to consider the effects of land use on (1) lek (traditional + temporary) versus non-lek points, and (2) traditional versus temporary lek types. The multivariate analysis simultaneously considered the 8 cover types we derived from the original 14. Subsequent to the MANOVA, we performed a stepwise discriminant function analysis to determine which land-use activities were associated most strongly with lek presence and lek type. This analysis uses the land-use pattern of the 3 lek types to build a discriminant function and then tests how well the function distinguishes the lek types. Because of the land-use pattern around a lek, however, the analysis may classify a non-lek location as a temporary lek, which is an incorrect classification.

We also analyzed land-use patch characteristics around leks by examining patch size and shape. These 2 variables were calculated for each natural land-use patch (i.e. forest, wetland, grassland, grass–shrub) that intersected or was within the 810-ha area surrounding a random point or lek. If a single land-use patch fell within or intersected >1 lek or non-lek type, we randomly assigned the patch to 1 of the categories to maintain statistical independence. We calculated Patton's diversity measure for patch shape:

$$\text{Shape index} = \text{patch perimeter}/2\{\sqrt{[\pi(\text{patch area})]}\}$$

(Patton 1975, Forman 1995). Patches that are perfect circles have a shape index of 1; as patch shape becomes more irregular, the index increases without limit. All patch size and shape data were transformed to the natural log to create more normal distributions. Eight ANOVAs were performed (4 natural land-use categories × 2 patch variables) to determine if patch characteristics differed among the 3 lek categories. We used SYSTAT 7.0 for all analyses (SPSS 1996).

RESULTS

Lek Versus Non-Lek Points

We found 389 unique greater prairie-chicken leks. These leks were used 866 times between 1986 and 1996, with many observed during multiple years (Fig. 2).

We found that locations of the greater prairie-chicken leks were strongly dependent on land-use characteristics as determined by the MANOVA (Wilks' $\lambda = 0.657$, $F_{3,433} = 75.49$, $P < 0.001$). Overall, the discriminant function correctly predicted lek versus non-lek status 87% of the time. Random non-lek sites were misclassified as lek sites more often (39%) than lek sites were misclassified as random (5%). The stepwise discriminant function analysis revealed that several land-use categories in particular were most important in predicting leks (Table 1). They were, in order of strongest discriminative power: forest ($F_{4,432} = 163.66$, $P < 0.001$), residential–farmstead ($F_{4,432} = 24.86$, $P < 0.001$), and CRP ($F_{4,432} = 4.94$, $P < 0.010$). Leks were associated with smaller proportions of forest and residential–farmstead areas, and greater amounts of CRP lands (Table 1). Surprisingly, proportion of grassland was not a statistically significant predictor when added to the stepwise model.

Patch analyses revealed differences among lek categories. Grassland patch size was greater at traditional leks than at temporary leks and random points ($F_{2,1416} = 13.5$, $P < 0.001$),

Table 1. Mean characteristics of 1990 land use surrounding traditional, temporary, and all leks combined, and random non-lek points in Agassiz Beach Ridges landscape, Minnesota, 1986–96.

	Traditional leks			Temporary leks			All leks			Random non-leks		
	$\bar{x}$	SD	n	$\bar{x}$	SD	n[a]	$\bar{x}$	SD	n[a]	$\bar{x}$	SD	n
Percent area[b]												
Cropland	43.9	18.4	43	49.8	18.5	294	49.1	18.6	337	41.6	18.5	100
CRP[c]	20.0	14.1	43	19.0	13.8	294	19.1	13.8	337	15.9	12.3	100
Transitional agriculture[d]	5.3	13.5	43	5.7	10.1	294	5.6	10.5	337	6.5	10.1	100
Residential–farmstead	0.3	0.3	43	0.7	0.7	294	0.6	0.7	337	2.7	5.9	100
Forest	1.6	1.5	43	3.1	2.9	294	2.9	2.8	337	11.0	9.7	100
Wetland	3.0	3.6	43	2.7	4.3	294	2.7	4.2	337	2.9	3.9	100
Grass–shrub	2.1	3.3	43	1.9	2.9	294	1.9	3.0	337	2.8	3.8	100
Grassland	23.2	14.7	43	16.6	12.5	294	17.4	13.0	337	14.5	11.1	100
Patch size (ha)[e]												
Grassland	53.2	154.6	117	17.2	75.2	741	22.1	91.1	858	12.3	56.6	561
Grass–shrub	6.2	18.9	59	4.8	19.9	406	5.0	19.7	465	5.5	12.5	224
Wetland	5.4	12.2	115	4.4	16.0	562	4.6	15.4	677	3.1	8.0	295
Forest	1.7	3.5	209	2.0	9.6	1087	1.9	9.2	2296	5.9	38.4	1186
Patch shape[e,f]												
Grassland	2.4	1.8	117	2.1	1.3	741	2.1	1.4	858	2.1	1.1	561
Grass–shrub	1.8	0.7	59	1.9	1.4	406	1.8	1.4	465	1.9	1.3	224
Wetland	1.6	0.7	115	1.5	0.6	562	1.5	0.6	677	1.5	0.5	295
Forest	2.1	1.2	209	1.9	1.0	2087	1.9	1.0	2296	2.0	1.0	1186

[a] We did not include 52 temporary leks whose surrounding area fell outside the landscape boundaries where land cover data were not available.
[b] Percentage of the area within the 810-ha buffer surrounding lek and random sites.
[c] Columns add up to more than 100% because 8% of CRP (Conservation Reserve Program) lands were digitized as a noncropland land cover type.
[d] Combines urban, farmstead, rural residence, other rural residential land-use types.
[e] The patches that intersect with the 1.6-km buffer surrounding lek and random sites. If intersected, the whole patch was measured, not just the area inside the 810-h buffer area.
[f] Patton's diversity index = patch perimeter/2$\{\sqrt{[\pi(\text{patch area})]}\}$.

which were not different from each other. Forest patch size was greater at random than at traditional and temporary leks ($F_{2,3479} = 11.0$, $P < 0.001$), which were not different from each other. Shape of grassland and forest patches surrounding traditional leks was more irregular than those surrounding temporary leks and random points ($F_{2,\ 1416} = 4.2$, $P = 0.016$ for grassland, $F_{2,3479} = 4.1$, $P = 0.017$ for forest). Size and shape of wetland and grass–shrub patches did not differ among lek categories.

Traditional Versus Temporary Leks

We classified 35 of the 389 leks as traditional. After examining the density of leks and searching for leks that appeared to be shifted to adjacent quarter sections, we classified 8 more leks as traditional. The remaining 346 leks were classified as temporary (Figs. 1, 2).

Annual male lek attendance and annual density of males on traditional versus temporary leks varied during the 11-year period. On average, 50 ± 8.3% of the total male attendance in the ABR landscape was on traditional leks, even though they averaged only 33% of all leks in any given year. Annual male density averaged 16.6 ± 3.8 males/lek for traditional leks, whereas temporary leks only had 8.1 ± 1.6 males/lek.

The MANOVA statistical model used to distinguish traditional from temporary leks based on land-use proportions was significant (Wilks' $\lambda = 0.938$, $F_{2,334} = 11.08$, $P < 0.001$), but less so than for lek versus non-lek points. The MANOVA had relatively poor predictive power, correctly predicting traditional versus temporary status only 64% of the time. Although less discriminative, there were several land-use types that were significant in the stepwise discriminant function analysis. Proportion of forest ($F_{3,333} = 18.13$, $P < 0.001$) and cropland ($F_{3,333} = 9.90$, $P < 0.001$) was lower surrounding traditional leks than temporary leks (Table 1). Traditional leks also had lower amounts of residential–farmstead and higher amounts of grassland (Table 1) within the 810-ha areas surrounding them, although these were not significant predictors ($P > 0.05$).

DISCUSSION

Lek Versus Non-Lek Points

The results of our land-use analysis were consistent with published field studies of greater prairie-chicken habitat preference, but we added the landscape perspective. Our data suggested leks at the landscape scale were located in areas with less residential–farmstead, smaller amounts and smaller patches of forest, and greater amounts of CRP than expected.

Residential areas and farmsteads generally are thought to be avoided by greater prairie-chickens because of associated threats and disturbances (Hamerstrom et al. 1957). Our results showed a lower proportion of rural residences near leks than around random non-lek points, and no traditional leks were found within 1.6 km of any town. Threats associated with such areas include planted windbreaks, which create perching sites for avian predators, and domestic pets in residential areas (Hamerstrom et al. 1957, Svedarsky et al. 1997).

Our results also suggested an avoidance of forest. No traditional lek was located within 1.6 km of a forest patch >30 ha, although many larger patches occurred in the landscape. Greater prairie-chickens tend to avoid forests because of unsuitable nesting habitat and avian and mammalian predators (Hamerstrom et al. 1957, Newell et al. 1987). Forests generally occur along stream corridors in the ABR landscape and in other low or broken areas where they historically survived prairie fires. The Wild Rice River is the largest riparian corridor in the ABR, running east to west, and may remove a large portion of the landscape from regular use by greater prairie-chickens. The closest lek was approximately 2 km away from this forested stream corridor.

Finally, a significantly larger proportion of CRP was found surrounding leks than random non-lek points, and CRP likely has a role in providing habitat. We surmise that the poorer soils near remnant prairies where greater prairie-chickens persist were more likely to be planted in CRP than were soils in intensive agricultural regions where prairie-chickens are no longer found. Studies have shown the importance of CRP for other grassland nesting birds (Kimmel et al. 1992, Reynolds et al. 1994, Roseberry et al. 1994). Lands in CRP that are planted with nonnative grasses and forbs may play a similar yet suboptimal ecological role as native grassland (Reynolds et al. 1994). Toepfer (1988) found greater prairie-chickens in Minnesota nesting in CRP and nonnative grasslands. Use often depended on habitat quality and management practices (Rosenquist 1996), and nesting success was lower in CRP than in native grasslands (J. Toepfer, University of Wisconsin-Stevens Point, unpublished data). Nonnative grasslands (CRP, transitional agriculture) vary considerably in quality, depending on the type of grass–forb mix planted and how they are maintained (Svedarsky et al. 1997).

The concept of 'ecological patterning' outlined for management of greater prairie-chickens articulated the need for scattered patches of managed grasslands within a mosaic of cropland (Hamerstrom et al. 1957, Svedarsky et al. 1997). This fragmented pattern was apparent in the ABR, with over 2,000 native grassland patches of varying sizes embedded in a landscape of cropland and CRP lands. Hamerstrom and Hamerstrom (1973) further suggested that larger leks generally are related to larger remaining blocks of native grassland. In the ABR landscape, 1 large native grassland tract of 656 ha supported 61 booming males in 1996 on 5 leks (3 traditional, 2 temporary). Thus, we were surprised that proportion and size of grassland patches were not significant predictors for lek versus non-lek points in this study, although grassland patch size did distinguish between traditional and temporary leks.

While agriculture has allowed greater prairie-chickens to expand their range into northwestern Minnesota during the past 100 years (Partch 1973), our data suggest prairie-chickens do not *require* agriculture near their leks or nesting sites. Distance from human settlement and forest, and available cover from CRP, appear to be most critical at the landscape scale.

Traditional Versus Temporary Leks

Reasons for the differences in patch shape between traditional and temporary leks were less obvious than habitat preferences of greater prairie-chickens. Our analysis showed that more irregular, complex-shaped forest and grassland patches were associated with traditional leks. Perhaps increased edges associated with irregular patches provide greater habitat diversity. Ecotone areas where grassland or forest intermixes with grass–shrub, CRP, crop, and wetland may provide diverse vegetation structure and increased food resources. How patch shape interacts with proportion and size of patches is not clear from this study. Predictive power for patch shape in both cases was low, and we caution against using shape as a predictive variable for management.

We believe the relatively poor ability to statistically discriminate between traditional and temporary leks was based on many potentially interacting factors. First, proportions of different land-use types were highly correlated. Even with the use of multivariate analyses, we had difficulty discerning the unique contributions of individual land-use types. For example, proportion of grassland and cropland were highly negatively correlated ($r = -0.49$), which may help explain why proportion of grassland was not a significant predictor (i.e., cropland was). Second, standard inaccuracies in coarse-level land-use data described earlier in this paper could have contributed to low statistical power. A third possible contributing factor was the use of a standard 810-ha circle surrounding leks. Actual use of areas surrounding leks is no doubt irregular in shape and distance. Fourth, we surmise that habitat quality for greater prairie-chickens is influenced by both landscape-scale and local-scale variables, and that finer-scale data or other coarse-scale information that we did not consider (e.g., distance to roads) may be necessary to better distinguish temporary from traditional leks and leks from non-leks. Finally, definition of traditional versus temporary leks was highly subjective. Occupancy criteria derived from more rigorous observations and analysis may help discriminate landscape-scale patterns of land-use better in future studies, and different criteria should be explored.

We recommend further study of lek stability in other landscape-scale research. As land use and management change over a broad scale (e.g., CRP contracts), traditional leks should be tracked to understand their temporal and spatial variability. Other important questions also remain unexamined. For example, can lek stability be defined more rigorously via population dynamics? How will leks, and in particular their stability, change over time with and without changes in land use? Does lek distribution and use vary at the landscape level during natural population fluctuations, and if so, how do they vary? We advocate examination of such questions at multiple scales and across multiple regions to assist in the broad-scale management of the greater prairie-chicken.

MANAGEMENT IMPLICATIONS

Grassland Restoration

We demonstrated that larger grassland patches are associated with traditional leks, and that these leks attract twice the number of males as temporary leks. We recommend expansion of grasslands in key areas to help maintain and expand greater prairie-chicken populations in the landscape. Managers can create larger patches by restoring native grassland between smaller grassland patches that lie close together. This approach will be most effective in regions away from natural forests (e.g., riparian areas, aspen–oak woodlands) and residential areas. Identifying locations for the most effective grassland restoration can be aided with GIS.

CRP

In addition to expansion of native grassland, our analyses showed that CRP was important for greater prairie-chickens and occurred in higher proportion around leks than around random non-lek sites. We believe CRP may be important, particularly at temporary leks, although our analyses did not show significant discriminative ability. Because native grassland patches near temporary sites generally were smaller, greater prairie-chickens may rely more heavily on nearby CRP at these lek types. Hence, land-use practices that increase and maintain CRP areas may benefit greater prairie-chickens at a broad scale.

Traditional Leks

Field studies have suggested more males can be supported at traditional leks due to better associated habitat (Hamerstrom and Hamerstrom 1973, Schroeder and Braun 1993), and our data supported these conclusions. For most wildlife species, individuals are distributed unevenly throughout a landscape, especially in highly fragmented regions (Fahrig and Merriam 1994), and different areas may be identified as sources or sinks for the overall population (Pulliam 1988). Protection of source areas obviously is vital to survival of the population as a whole (Petit et al. 1995). Because traditional leks, on average, supported more males than temporary leks, they may function as source areas for the total population of greater prairie-chickens in the ABR. Thus, traditional leks and native grasslands surrounding them have potential to help prioritize and guide management and protection efforts at the landscape scale.

Multiscale Management Approach

Our analysis showed that random points were often (39% of the time) misclassified as greater prairie-chicken leks. In addition, our model only detected moderate statistical differences in land-use patterns and patch characteristics between temporary and traditional leks. As mentioned previously, habitat quality for greater prairie-chickens is determined at multiple scales, and discriminative power for lek type probably could be improved with additional fine-scale information. Factors such as plant diversity, insect abundance, vegetation structure, and litter are critical to greater prairie-chickens at different stages of their life cycle (Svedarsky et al. 1997, McKee et al. 1998). Thus, we advocate a multiscale approach to management of greater prairie-chickens. For example, managers should consider studying population viability and demography in conjunction with fine-scale habitat variables and land-use patterns (Fahrig and Merriam 1985, Ruggiero et al. 1994, Dunning et al. 1995). A multiscale approach could involve use of spatially explicit population viability models to examine greater prairie-chicken population dynamics at the scale of the ABR landscape (e.g., Lindenmayer and Lacy 1995).

ACKNOWLEDGMENTS

Financial support was provided by The Nature Conservancy's Rodney Johnson and Katherine Ordway Stewardship Endowments. We thank J. E. Toepfer and W. D. Svedarsky for project and manuscript review, and the Minnesota Chapter of the Prairie Chicken Society and the Minnesota Department of Natural Resources for greater prairie-chicken lek data. N. L. Staus provided statistical advice and manuscript review, and G. D. Maddox completed the statistical analyses and assisted in interpretation. H. M. Watson gave GIS technical support. Land-use data were obtained from the Land Management Information Center, Minnesota Department of Planning, and CRP data from the Minnesota Department of Agriculture under a grant from the Legislative Commission on Minnesota's Resources.

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Received 19 June 1997.
Accepted 8 June 1998.
Associate Editor: Lutz.